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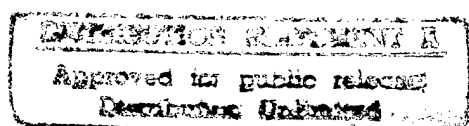Report No. SID/TR-96/0101

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TECHNICAL REPORT/STUDY SERVICES — Functional Description

for

Army Logistics Assessment Program

Prepared for

HQ USA/DALO-RMI
500 Army Pentagon
Washington, DC 20310-0500

21 June 1996

Prepared by

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This report has been approved for publication.

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FOR THE COMMANDER

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The proof-of-concept model for ALAP demonstrates the feasibility of equating Army measures of OPTEMPO, maintenance rates, and funding levels to sustainment capability. Synergy's ALAP shows that we can link weapon system readiness to sustainability given current and future programmed budget positions to create a viable POM and PPBES decision-support tool. This model also supports the hypothesized outcome of current funding levels affecting future capabilities to successfully prosecute combat missions and contingency operations.

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LIST OF ACRONYMS

AIS	Automated Information Systems
ALAP	Army Logistics Assessment Project
AMC	Army Materiel Command
ASCII	American Standard Code for Information Interchange
CIF	Candidate Item File
CPU	Central processing unit
DBOF	Defense Business Operations Fund
DIF	Data Information Format
DLR	Depot-level reparable
DMM	Data Management Module
DOD	Department of Defense
FAMMAS	Funding/Availability Multi-Method Allocation for Spares
FD	Functional Description
FMS	File management system
FY	Fiscal year
FYDP	Future-Year Defense Program
MB	Megabyte (approximately 1,000,000 characters of storage)
MC	Mission capable
MPDL	Master Profile Data List
MSC	Major Subordinate Command
MS-DOS	Microsoft Corporation Disk Operating System
NMC	Not mission capable
NMCM	Not mission capable, maintenance
NMCS	Not mission capable, supply
OCA	Operating cost authority
OPTEMPO	Operating tempo
OSD	Office of the Secretary of Defense
PEO	Program Executive Office
POC	Point of Contact
POCM	Proof of Concept Model
PPBES	Planning, Programming, Budgeting, and Execution System
RAM	Random Access Memory
RIDB	Readiness Integrated Data Base
SMBA	Supply Business Management Area
TRADOC	Training and Doctrine Command

EXECUTIVE SUMMARY

In today's Department of Defense fiscal environment of continuous need to justify and balance expenditures that sustain operational capability, all services, especially the Army, are concerned about decreasing readiness levels as they relate to reduced funding in important supply, maintenance, and operations accounts.

Historically, modeling has been used to help justify necessary expenditures, perhaps because it is the most successful vehicle for gathering and structuring costs and operational data. Refinement of modeling techniques, when coupled with the improved capabilities of microcomputers, has made possible a new generation of fast, portable models that can provide analysts with authoritative, reliable information on the impact of funding options in time to influence budget decisions.

In the course of developing an approach for quickly assessing the impact of programming and budgeting decisions on weapons system availability, Synergy designed a set of parametric models for macro-level logistics budget analyses for the United States Air Force, Deputy Chief of Staff Logistics, and Deputy Chief of Staff for Plans and Operations. To preclude adverse mission capable rate trends in the Army's 16 primary weapons systems in a period of continued constrained funding, the Army began to investigate the potential use of Air Force's Funding/Availability Multi-Method Allocation for Spares (FAMMAS) model to monitor their weapons systems sustainment and readiness. In 1993, the Army agreed to perform testing on the applicability of the use of the Air Force FAMMAS model as a resource allocation tool within the Army. From December 1993 through March 1995, Army FAMMAS has been incrementally tested with favorable results. In March 1995, the Army gave the go-ahead to Synergy for development of an Army FAMMAS in a Windows environment. During the same time, the Army contracted with Synergy to enhance the army version of FAMMAS by developing and installing a function that enables the Army to perform cost effect trade-offs for funded and/or proposed weapon system modifications. The enhancement project, which became known as the Army Logistic Assessment Project (ALAP) also called for adapting standard army OPTEMPO measures for use within Army FAMMAS and a wartime model.

With the concept of how resource trade-offs affect weapon systems materiel readiness as its basis, Army FAMMAS creates a framework for analysis using data and computational procedures that are accepted in the Army. The model draws on evolutionary improvements in cost analysis and availability modeling. It builds on this foundation using advanced techniques of interactive data display and manipulation on microcomputers. Army FAMMAS uses a new approach to resource relationships in order to generate rapid predictions of weapons system materiel readiness. The ALAP Proof of Concept Model (POCM) generates predictions of weapon system availability and sustainment capability. It takes the supply and maintenance capability rates

developed by Army FAMMAS and goes to the next logical step. Army FAMMAS and the ALAP POCM together will provide weapon system availability readiness rates and sustainment capability given current funding levels and budget constraints.

From a technical viewpoint, Army FAMMAS can best be described as a microcomputer-based program, written in Borland's Delphi, that is designed to relate projected spares support and manpower availability to future weapons system material readiness. Army FAMMAS links funding for depot-level reparable spares and repair to expected weapon system not mission capable, supply rates. Army FAMMAS also relates projected equipment usage operating tempo (OPTEMPO) and repair potential (manpower levels and utilization) to not mission capable, maintenance rates. The ALAP POCM uses OPTEMPO, availability of spares, weapon system parts and component failure rates, and repair potential set in a contingency environment to analyze sustainment capability. Army FAMMAS/ALAP POCM uses dynamic, interactive displays that are backed by cost models and parametric equations to quickly estimate the effect on no mission capable rates of different levels of wholesale level operating cost authority allocated to key accounts in the Supply Business Management Area segment of the Defense Base Operations Fund.

The Army's vision development of this powerful resource allocation tool has come to fruition. The Army FAMMAS model can quickly assess the operational impact of proposed changes in the funding of DBOF logistics resources among the Army's major weapons systems. The model should serve as a highly valuable resource allocation tool at all levels of the Army's Planning, Programming, and Budgeting Execution System.

SECTION 1

GENERAL

1.1   PURPOSE OF THE FUNCTIONAL DESCRIPTION

The functional description (FD) for the Army Funding/Availability Multi-Method Allocator for Spares (FAMMAS) and Army Logistic Assessment Program (ALAP) Proof of Concept Model (POCM) is written to provide the following:

- System requirements that will serve as a basis for mutual understanding between the user and the developer.

- Information on performance requirements, preliminary design, and user impacts.

- A basis for the development of system tests.

This FD is organized according to the guidelines in DOD-STD-7935A, Military Standard, DOD Automated Information Systems (AIS) Documentation Standards (31 October 1988). Section 2 discusses performance characteristics and failure contingencies of FAMMAS, while Section 3 gives a more complete view of the workings of the model and its algorithms. Section 4 discusses the FAMMAS and ALAP POCM environment, and Sections 5 and 6 address security and cost factors associated with running the model.

1.2   PROJECT REFERENCES

The project sponsors for Army FAMMAS and ALAP are DALO-RMI, Secondary Items Division, Office of the Deputy Chief of Staff for Logistics, Headquarters, Department of the Army, AMCLG-SR Associate Director of Requirements, Director of Materiel Management, Deputy Chief of Staff for Logistics, Headquarters, U.S. Army Materiel Command.

The model uses budget and operational data related to the logistics and operations communities and develops a variety of information depending upon which module the analyst selects. The model is used by the Army to provide logistics and operational participants in the programming and budgeting process with rapid information to support decisionmaking.

Applicable project references are as follows:

AF/LEXI/Synergy, Inc., Logistics Capability Support Analysis Studies, Windows Integrated Logistics
    Assessment Model (WINLAM), Funding/Availability Multi-Method Allocator for Spares (FAMMAS),
    Functional Description, September 1995.

CALIBRE Systems Inc./Synergy, Inc., *Assessment of the Army's SORTS Weapon Systems, MD903-92-D-
    0049/032*, 30 November 1994.

DOD-STD-2167A, *Military Standard, Defense System Software Development*, 26 February 1988.

DOD-STD-2168, *Military Standard, Defense System Software Quality Program*, 29 April 1988.

DOD-STD-7935A, *Military Standard, DOD Automated Information Systems (AIS) Documentation Standards*,
    31 October 1988.

HQ USA/DALO-RMI/Synergy Inc., Army Funding/Availability Multi-Method Allocator for Spares (Army
    FAMMAS) Model (Windows), *Functional Description*, March 1996

1.3 <u>TERMS</u>

Defense Guidance	The Department of Defense (DOD) strategic plan for the development and employment of future forces. Provides the Secretary of Defense's threat assessment policy, strategy, force planning, resource planning, and fiscal guidance to all DOD organizations.
Equipment Readiness	A logistic indicator that portrays the combined impact of equipment shortages and maintenance shortfalls on a unit's ability to meet wartime needs.
Planning, Programming, Budgeting, and Execution System (PPBES)	The primary management system used by HQDA to establish and maintain the Future-Year Defense Program and budget (FYDP). Used to administer the resource allocation process, the PPBES helps ensure Army capabilities needed to accomplish assigned objectives as well as effective use of available resources.
Readiness	The capability of equipment or a unit/formation, ship, or weapons system to perform the mission or functions for which it is organized and designed.
Sustainability	The capability to maintain the required level (intensity) and duration (time) of military operations to achieve the planned objectives or outcomes. It represents the balanced capability for all logistics and combat service support (Arm, Fuel, Fix, Move, and Soldier Support) functions that provide the staying power over time for the supported force. Includes the force structure, prepositioned and war reserve materiels, prescribed loads and operating stocks, and wholesale sustaining and industrial base that, in their totality, comprise Army capability to project and reconstitute the Total Army Force.

1.4   **OFFICES**

DALO	Deputy Chief of Staff for Logistics
DALO-RMI	Secondary Items Division, Office of the Deputy Chief of Staff for Logistics, Headquarters Department of the Army
AMCLG	Deputy Chief of Staff for Logistics, Headquarters, U.S. Army Materiel Command (AMC)
AMCLG-SR	Associate Director of Requirements, Director of Materiel Management, Deputy Chief of Staff for Logistics, Headquarters, U.S. Army Materiel Command
AMXLS-RRS	Readiness and Sustainment Center, U.S. Army Materiel Command Logistics Support Activity (LOGSA)
AMXSY-LM	Logistics Studies and Methodology Branch, Logistics Analysis Division, U.S. Army Materiel Systems Analysis Activity (AMSAA)
AMSTA-IM-KPF	AMC, Tank and Automotive Command (TACOM)
AMSAT-I-SPFF	AMC, Aviation and Troop Command (ATCOM)
AMSMI-MMC-BM-DD	AMC, Missile Command (MICOM)
AMSEL-LC-MMO-SB	AMC, Communications and Electronics Command (CECOM)
AMSTA-AC-MCIPP-AM	AMC, Armaments and Chemical Acquisition and Logistics Activity (ACALA)

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SECTION 2

DETAILED CHARACTERISTICS

2.1   SPECIFIC PERFORMANCE REQUIREMENTS

This section describes specific performance characteristics of Army FAMMAS/ALAP. These characteristics are essentially identical to those enumerated for Army FAMMAS, they include the accuracy of mathematical calculations, timing, and storage capacity requirements, as well as a general discussion of inputs and outputs.

2.1.1   CAPACITY REQUIREMENTS

Army FAMMAS and the ALAP POCM are designed to run on any IBM-compatible system having an 80386 CPU chip or better (preferably with a coprocessing unit), using Windows 3. 1 or higher, and having storage capacities of at least 4 megabytes of random access memory (RAM) and 1.5 available megabytes of hard disk space. Faster processors and larger storage capacities will, of course, improve the operation of the program.

2.1.2   TIMING

Army FAMMAS has been designed as a quick-response model to respond to the need for not mission capable, supply (NMCS) and not mission capable, maintenance (NMCM) estimates and weapon system availability. The actual running times will vary with the particular machine on which it runs, but response times of less than a minute to do a calculation for one or more weapon systems are not unusual.

2.1.3   NUMERIC ACCURACY

Numeric data entered into Army FAMMAS/ALAP will consist of real number data and integer data. Real data will be used to represent dollar amounts and readiness percentages as well as various quantities associated with NMCM calculation and model parameters. Dollar amounts will be input and output to an accuracy of one decimal place. This will represent dollar values to the nearest $100,000 when inputs are in millions, as is expected for the usage of the model. Readiness percentages will be input and output to the nearest .01 percent. Lead time factors, carryover factors, and inflation rates will be entered to the nearest whole percent, as will the consumables deficit factor. Funding limits as percentages will be entered to the nearest whole percent. The current year adjustment factor will be entered as any other NMCS figure, to two decimal places. The number of months to adjust is an integer value. Section 4 gives a more complete explanation of the meanings of these different sets of values.

2.1.4   INPUTS

The file management system (FMS) operates to collect saved data from a set of files. Input data are edited and maintained by weapon system key and year in the FMS library until called for. These input data, maintained in dBASE IV formatted files, are called upon by the Army FAMMAS data management module (DMM), which assembles data in a format that the analysis modules can use directly. There is also a capability in Army FAMMAS to read ASCII files for certain kinds of data. See the User's Manual for a more complete description.

DMM files contain all of the data associated with a model run. Data are retrievable through an editing system in the DMM and are moved into RAM when the file is selected. Capacity is a function of the number of files stored and the capacity of the hard disk of the microcomputer system in use. More information on the FMS and the DMM can be found in Section 3.

In addition to saved file input, the program allows the user to input manually his or her own figures for any of the data categories. There are, however, two categories of use defined in the program — standard and advanced. The standard user does not have access to changing certain of the data values. This is discussed further in Section 3, where a set of required inputs is listed.

2.1.5   OUTPUTS

Outputs generated during Army FAMMAS's operation include all interactive screens and are almost too numerous to catalog. The more significant outputs are selected by the user through several menu-display options. Outputs include on-screen tables displaying static data from the Army FAMMAS data set that can be viewed or edited. Therefore, virtually all input and computational data elements can also be considered output data elements as reflected in the following sections. Graphical and tabular screen representations from the model's dynamic graphing screens are also available. Both graphical and tabular output formats can also be printed using the Army FAMMAS report generator to give the user hard copy products from which to analyze results. Graphics can be output to files in BMP and WMF format for use with PowerPoint, Freelance, and Harvard Graphics. Reports can be output to files in a variety of formats, including WYSIWYG, character-, comma-, and tab-delimited ASCII files, spreadsheet formats including LOTUS 1-2-3, EXCEL, and Quattro Pro, wordprocessor formats for Word for DOS and Windows and WordPerfect, Crystal Reports format, and DIF (data interchange format).

2.2   <u>FAILURE CONTINGENCIES</u>

There are no built-in features in Army FAMMAS that account for machine failures, power losses, or other problems. In preparation for failures of any kind, the user should maintain a working copy of the model and the most recent database on floppy diskettes or a cassette tape cartridge if possible. The user should also know of an alternate machine with a compatible environment for Army FAMMAS processing in case of machine failure, damage, or loss.

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SECTION 3

DESIGN CONSIDERATIONS

3.1   <u>**GENERAL DESCRIPTION**</u>

With the concept of how resource trade-offs in peacetime affect weapons system materiel readiness as its basis, Army FAMMAS creates a framework for analysis using data and computational procedures that are accepted in the Army. The ALAP POCM uses weapon system materiel readiness and maintenance support availability as its basis for sustainment analysis. The model draws on evolutionary improvements in cost analysis and availability modeling. It builds on this foundation using advanced techniques of interactive data display and manipulation on microcomputers. Army FAMMAS uses a new approach to resource relationships in order to generate rapid predictions of weapons system materiel readiness.

From a technical viewpoint, Army FAMMAS/ALAP can best be described as a microcomputer-based program written in Borland's Delphi that is designed to relate projected spares support and manpower availability to future weapon system materiel readiness. Army FAMMAS links funding for depot-level reparable (DLR) spares and repair to expected weapon system NMCS rates. Army FAMMAS also relates projected equipment usage (operating tempo [OPTEMPO]) and repair potential (manpower levels and utilization) to NMCM rates. Army FAMMAS uses dynamic, interactive displays backed by cost models and parametric equations to quickly estimate the effect on not mission capable (NMC) rates of different levels of wholesale-level operating cost authority (OCA) allocated to key accounts in the Supply Business Management Area (SBMA) segment of the Defense Base Operations Fund (DBOF).

Operational capability is initially designed into a weapon system and then supported with an expensive array of ground-based equipment and personnel resources that are in every sense a part of the weapon system's capability. Spare parts and the repair skills to install them are a central part of the weapon system's capability package because they determine availability of the system for a mission. Unfortunately, the recurring nature of a weapon system's supply and maintenance costs make them vulnerable to budget cuts as other weapon systems and programs compete for limited defense resources. There is, therefore, a continuous need to justify and balance expenditures that sustain a weapon system's materiel readiness and sustainment.

Army FAMMAS/ALAP was developed as a microcomputer-based model to help the HQDA, HQ AMC, the Major Subordinate Commands of AMC (MSCs), the Program Executive Offices (PEOs), and other interested agencies to address resource issues related to weapon system materiel readiness. The configuration of Army FAMMAS and development of Army FAMMAS data sets will be managed by HQ AMC and LOGSA. Army

FAMMAS software as well as an Army FAMMAS data set will be provided to HQDA, HQ AMC, its MSCs, and other agencies to run on their own microcomputers. The Army FAMMAS/ALAP POCM, data and software, however, will be provided only to HQ DA and HQ AMC.

3.2   ARMY FAMMAS COMPONENT MODULES

There are two Army FAMMAS (plus the ALAP model that was developed and configured as a module to Army FAMMAS) assessment modules available to the planner/budget programmer/analyst (Figure 3-1). These conform to the supply and maintenance aspects of analysis discussed above. The Army FAMMAS supply module determines peacetime NMCS based on a broad set of funding resources for secondary item supplies. The Army FAMMAS maintenance module determines peacetime NMCM based on OPTEMPO, maintenance manpower fill rates, and maintenance manpower utilization in the repair of items. Together both modules predict the mission capable (MC) rate for each of the Army's major weapon systems. The ALAP POCM is the third module, it determines the logistic systems capability to sustain a weapon system and predicts a systems availability given such parameters as combat OPTEMPO, spares breakrates, spares and maintenance availability.
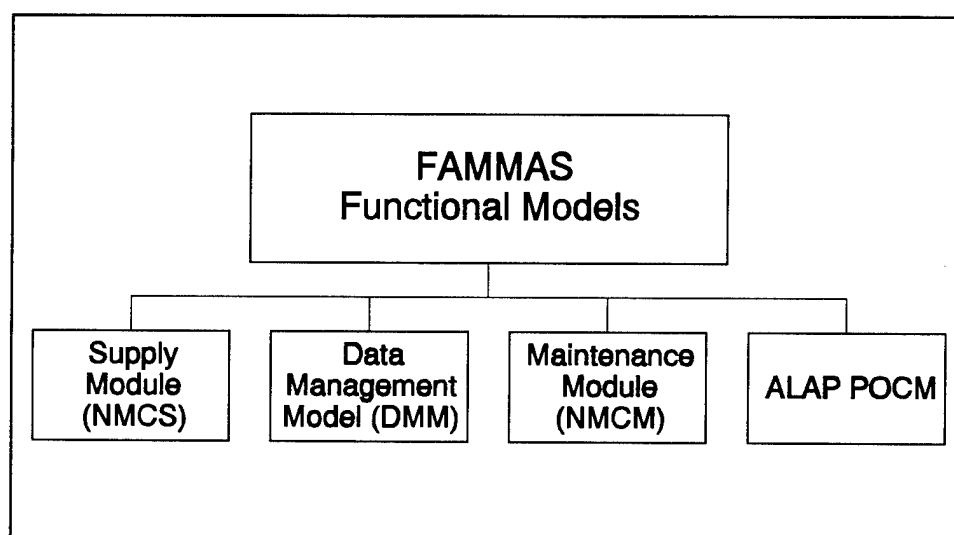

Figure 3-1. Army FAMMAS Component Modules

3.2.1   ARMY FAMMAS SUPPLY MODULE

This version of the supply module is an improvement to a DOS version used previously to do sample computations for the Army. It provides for the input of DLR buy funding data, DLR initial spares funding, DLR repair funding and consumables funding, with the resulting output of an NMCS value for each system.

There are 8 years in which funding data are entered, 4 of which are for historical data and 4 of which contain estimates of funding for the future. Historical values of NMCS are entered for the first 4 years, and the model calculates NMCS for the later years.

The model can address a single weapon system or a group of weapon systems taken together, and will automatically allocate DLR buy funding among weapon systems in the multiple weapon systems mode. (See Figure 3-2.) At the user's option, DLR buy funding in a particular year can be spread across multiple systems using a proportional spread or a model optimization scheme, or can be entered by the user for each system in the course of running the program. (There is no provision currently to allocate funds simultaneously in more than 1 year to optimize availabilities in 1 or more years.)
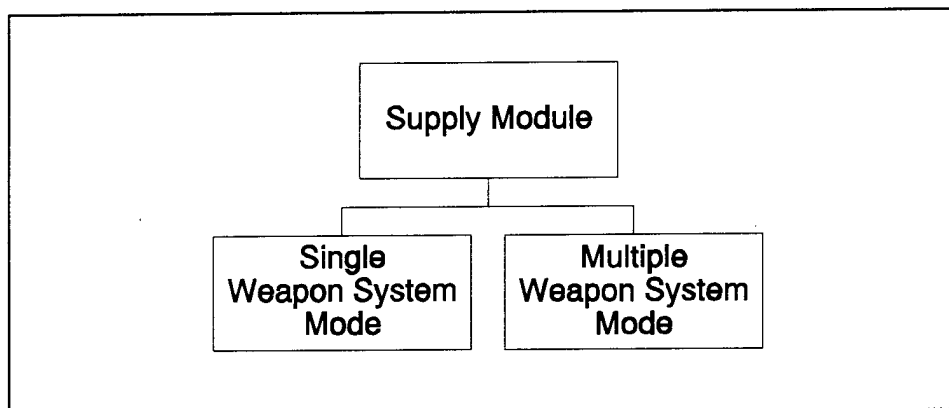
Figure 3-2. Supply Module Components

The techniques of the program can also be used in combination. By properly grouping weapon systems, the user can, for example, set funding levels manually for some systems, spread money proportionally for another group (or groups) of systems, and optimize the spreading of funds for still other groups of systems.

The optimization feature allows the spreading of funds in a chosen year to reach target availability criteria in 1 year or in multiple years. This is a sequential optimization approach, where different years are given priorities and the program can address stated objectives for multiple years in the order of their priorities. Spreading techniques are explained below.

3.2.2   ARMY FAMMAS MAINTENANCE MODULE

A maintenance module has been added in this version of the model. The maintenance module is the portion of Army FAMMAS that addresses the effect of manpower on weapon system availability rates. This module operates independently of the NMCS module and uses different input data. NMCM values are predicted for

future years based on the expected activity of a system (OPTEMPO) and the manpower available to repair it. The factors used in the maintenance module are shown in Figure 3-3.
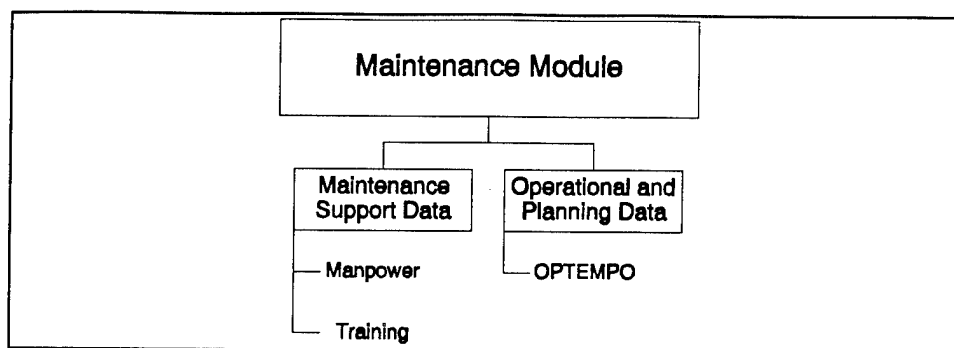
Figure 3-3. Maintenance Module Architecture

A study was done of existing NMCM data and the factors that correlate with it. The analysis of the data showed that NMCM values in a particular year are related to the manpower available in that year for repair work, but are related to OPTEMPO more closely in the year **prior to** the year in question. Formulas have been set up accordingly.

In some cases there are no good data for OPTEMPO for a weapon system, usually because there is no good definition of a measure of OPTEMPO for that system (e.g., some artillery and air defense weapon systems). In such cases, the model does not try to **predict** NMCM but rather extrapolates the trend in NMCM values observed in prior years. Separate formulas are used for these systems.

3.2.3   **DATA MANAGEMENT MODULE (DMM)**

The principal functions performed by the Army FAMMAS/ALAP DMM are shown in Figure 3-4 and include selecting weapon system records at an appropriate level of aggregation, viewing and editing factor and cost data associated with weapon system records, comparing data records, displaying records, adding records, deleting records, saving records, and printing records. The components of the DMM are an FMS, a capability for editing data within the program, a report generator, various tools for the user, and a help system. The Army FAMMAS DMM is the same DMM used by the ALAP POCM, however, two exceptions exist. While in the ALAP mode of the Army FAMMAS model, the help system and the user tool are disabled.
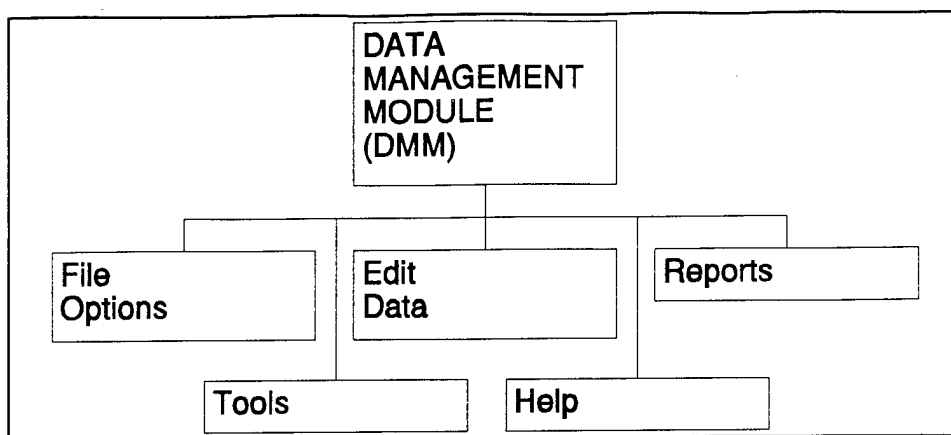
Figure 3-4. Data Management Module Functions

3.2.3.1   **The File Management System**

File options are accessed through the Dataset menu. The file options, shown in Figure 3-5, are standard file functions — open, save as (save under another name), save, delete, and import. (Files in different formats can be imported for use in Army FAMMAS.) The base year can also be selected using this menu. (See below for definition of base year.)
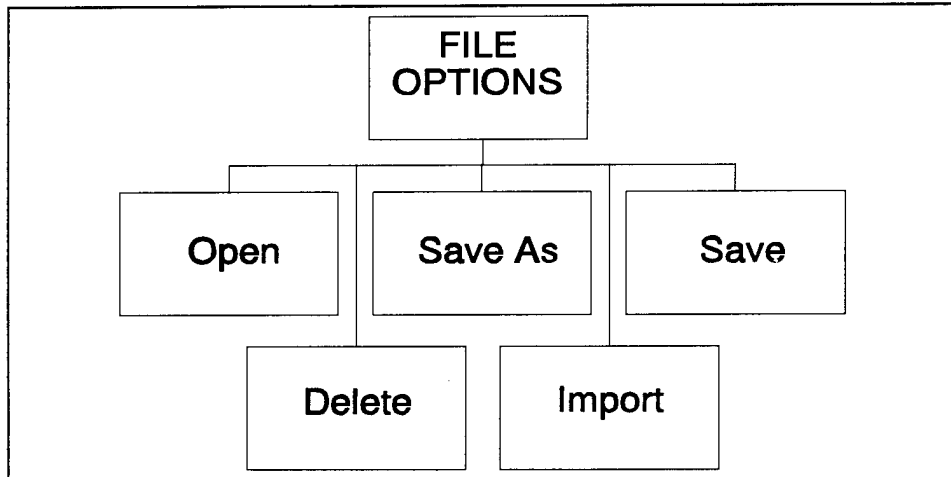
Figure 3-5. File Options

The file formats allowed by the import function are formats that could be produced by any popular spreadsheet or word processor. The Import NMCS function requires quarterly NMCS and NMCM data for historical years. These data will be taken from the Readiness Integrated Data Base (RIDB) maintained by LOGSA of AMC. The data from the RIDB must be in a space-delimited ASCII file (one per system/subsystem) organized as shown below.

3-5

CODE	FSC	NIIN	FMC	PMC	NMCS	NMCM	Q/OH	DATE
1520	011069519	63	0	12	25	37	8903	
1520	011069519	61	0	13	26	68	8906	
1520	011069519	58	0	14	28	45	8909	
1520	011069519	57	0	13	30	50	8912	

The FSC and NIIN columns are ignored by the import, but the others require explanation. Data are collected only from rows with a blank entry in the CODE column. The NMCS and NMCM columns contain percentages for NMCS rates and NMCM rates, respectively. The MC rate could be computed by adding the columns FMC and PMC, but since the MC rate is always 100 − NMCS − NMCM, the two columns are ignored. Each row contains rates for a single quarter, but the program works only with annual averages. The annual average is not a straight average, but is weighted by the quarterly quantity on hand, read from the Q/OH column. The DATE column indicates the calendar year and last month of the fiscal quarter for each row. In the example, the NMCS for the year 1989 would be computed as

$$(12 \times 37 + 13 \times 68 + 14 \times 45 + 13 \times 50)/(37 + 68 + 45 + 50) = 13.04.$$

There is a requirement, however, that all four quarters must be present (four lines) in order for the program to read the information for a year. This complicates things when the current year is to be included in the FAMMAS calculations of NMCS and only partial information is known. (See explanation below for description of the use of Current Year Adjustment.) In this case the user will be required to add a dummy line or lines to the file with data for the last quarters of the current year. There are various options for the numbers to use for NMCS for these quarters. For example, the last quarterly value could be repeated. However, it is probably more in keeping with the spirit of the current year adjustment to make the NMCS value for the dummy quarter(s) equal to the average value of the known quarterly values for the year.

Further requirements on the files are as follows: (1) columns must be delimited by spaces, not tabs; (2) columns are left-justified; (3) columns must left-align with their headers; and (4) all four quarters of each fiscal year must be presented in order for the annual average to be computed for the model.

The Import NMCM function requires annual personnel fill rates for future years in a tab-delimited ASCII file organized as shown below:

MOS	FY	Py Grd	O/H Tng	Proj Tng	Tgt Tng	O/H Op	Proj Op	Tgt Op
13B	1996	3	3615	3362	3212	3552	3264	3118
13B	1996	4	3960	3985	3932	3808	3832	3781

These data are taken from the Total Army Personnel Command and are used only for the prediction of NMCM from usage and manpower factors, as opposed to the extrapolation of NMCM values. (See explanation in a later section of the different approaches to NMCM calculation.) Each system has two fill rates: an indirect fill rate corresponding to the higher pay grades in this file (represented in the Py Grd column as 6 and higher) and a direct fill rate corresponding to the lower pay grades (represented as 5 and lower). The two fill rates for each year are computed by the following procedure: collect all the lines with the appropriate fiscal year (read from the FY column), pay grades, and MOS classifications, take the ratio of the on-hand operational personnel count (O/H Op column) to the on-hand trained personnel count (O/H Tng column) to get the fill rate for each row, and then take a straight average of all the fill rates. The other columns (Proj Tng, Tgt Tng, Proj Op, Tgt Op) are not used for fill rate calculations. In the example, the fill rates for the two lines would be 3552/3615 = .98 and 3808/3960 = .96, respectively. These would be averaged in with all other lines for which FY = 1996, Py Grd is less than 6, and the MOS value matches the weapon system in question. The data for the ALAP POCM come from three sources. None of the data is user input. Since the model was developed as a Proof of Concept, the option of importing or changing options was considered an unwarranted luxury. The Candidate Item File (CIF) provided by LOGSA contains the majority of data used by ALAP. The CIF is received in electronic form and the data for each specific weapon system is broken out and manually manipulated until the results yield the number of parts requested per each instance of the weapon requiring repair and maintenance, and the average of the mean hours (or some other operating tempo) between failure. Combat OPTEMPO is derived from the Master Profile Data List (MPDL) and the spares availability and maintenance availability is imported from their respective modules of Army FAMMAS.

3.2.3.2   Data Edit System

Figure 3-6 presents the edit options, which are accessed through the Edit menu. The Edit menu becomes available whenever an individual system is selected, either in single or multiple system mode. The data categories displayed represent the standard editing screen. Another option is available — the advanced user option. The advanced edit selections include a variety of funding and personnel parameters, which do not normally require modification for a model run.
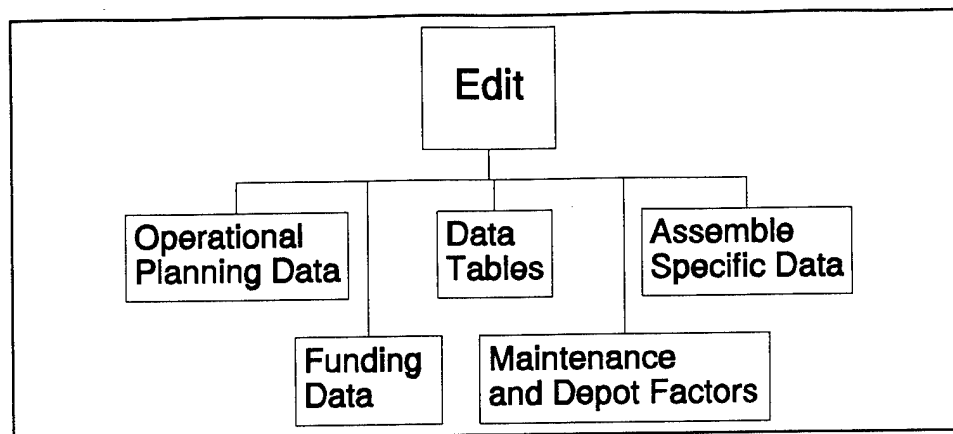
Figure 3-6. Edit Options, Standard User Level

3.2.3.3 <u>User Tools</u>

Tools available to the user, outlined in Figure 3-7, include setting the user level and access to a comment screen (which uses the Notepad editor). There are two user levels — standard and advanced. The advanced user is able to access and change historical data and parameters to be used in the analysis calculations, such as lead time factors and carryover factors. Access to the advanced user level is password protected. The advance user option is accessible within the ALAP POCM, but changing from user level does not affect available options.
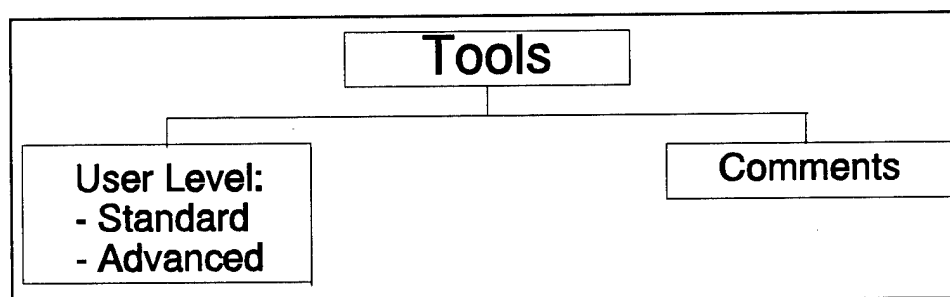
Figure 3-7. Tools Options

3.2.3.4 <u>Data Control Methodology</u>

The model uses a multilevel system of several files to store the information for a complete set of weapon systems. There are two header files in the main directory and a subdirectory, with the same name as these files, which contains the actual data files. The program will create this subdirectory in the directory in which the user is working whenever a new set of data files is created (i.e., when a new name is given to the save

file). Additionally, there is a file set supplied with the program called FAMDS, which contains the latest data values for the systems it addresses; the contents of FAMDS cannot be changed by using the Save File option. To change FAMDS it is necessary to use the Save As option and to respond properly to questions that will be asked. Even so, FAMDS cannot be changed in this way unless the user has logged on as an advanced user. (Thus FAMDS effectively becomes a reference data set.)

The program also creates a subdirectory for its own use called Working. This subdirectory is used during the execution of the program to store intermediate results and should not be changed or accessed by the user.

3.3 REQUIRED INPUTS TO THE MODEL

This section discusses the information that must be input into the model by the user to perform NMCM and NMCS calculations. Although the ALAP POCM requires no user inputs except the number of weapon systems to be analyzed, the Army FAMMAS model must be run prior to running ALAP. This is significant because it requires the user to input all required Army FAMMAS data to have a successful execution of the ALAP POCM. In the discussions that follow, the terminology used is as defined here:

- *Base Year.* The year immediately preceding the current year. This year is used for calibration of functions in the model, since it is assumed that both historical funding and availability data are available for that year. The model allows the user to change the base year, at his or her option, while retaining the data already input. In the examples shown in this section, the base year is 1995.

- *Allocation Year.* A year after the base year that the analyst has selected to allocate funding. (e.g., if he or she is reallocating or developing recommended funding spreads for 1996, that is the allocation year).

- *Assessment Year.* In the multiple weapon system mode, as funding levels are changed the model looks into the future to determine how funding should be spread. The year that it looks at is the assessment year. For example, if the allocation year is 1996, the assessment year could be 1996, 1997, 1998, or 1999. (Note that changing the allocation in one year will alter weapon system availability for several years beyond.)

The user must supply the following information to use the Army FAMMAS model.

Funding Data. As stated above, the user must input required funding and obligated funding dollars for each of the categories: DLR Buy, DLR Initial Spares, Consumables, and DLR Repair. This is done by year of obligation, both for historical year (those preceding and including the base year) and for future years. Generally speaking, only the advanced user will be allowed to modify the historical data, while the standard user will be able to change future funding figures in order to calculate the effects of different funding levels and of changing requirements. Funding data are obtained from the DBOF.

The model allows percents to be entered for obligated funding if desired, and calculates the actual dollars as a percentage of required dollars. (If dollars are entered, the model calculates the percentage of requirement funded.) The advanced user is allowed also to specify maximum and minimum allowable funding values in the buy category for each system. These numbers are used when the model is asked to spread buy funding over several weapon systems. The maximum amounts are input as a percent of the required buy funding, while the minimum amounts are entered as dollar values.

Lead Time Factors, Carryover Factors, and Inflation Rate. As stated above, the user specifies lead time and carryover factors to be used in the model. If no carryover is desired, then the user need only deactivate the Use Carryover button. It will not be necessary to enter any carryover data. If carryover is used, then the estimated costs of the carried over items are increased to account for inflation's effect, and the user must specify an inflation factor for each year.

Historical Mission Capable Rate Information. Army FAMMAS requires historical NMCS and NMCM data for each weapon system. Historical NMCS data are required for the base year and are used to calibrate the NMCS marginal return curves. While not essential to its operation, similar data for the 3 years prior to the base year enable the model to better illustrate past trend information. Similarly, historical NMCM data are used to derive parameters for the equations that compute future NMCM values. In the case of NMCM, the historical values for the base year and the 2 previous years are used in setting the equation parameters. Historical NMCS and NMCM data for this input are obtained from the RIDB maintained by LOGSA.

Availability Targets (1 − NMCS). Availability is defined to be equal to 1 − NMCS for purposes of the model. The model requires NMCS targets as an input to calibrate the marginal return curves for availability. The assumption is made that the stated OCA requirement is based on the weapon-specific MC goal and is the amount needed to achieve that goal. (This assumption is modified somewhat in the calculation, depending on the match between base year target information and base year achieved NMCS.) NMCS and NMCM targets are taken from AR 700-138.

Current Year Adjustment. The model has an optional feature that allows the user to adjust future-year NMCS projections based on current weapon system NMCS information. (Current year is the next year after the base year and represents the fiscal year [FY] currently in progress. The NMCS figure will represent an estimate of NMCS for that year based on the partial information available.) This feature may be toggled on or off; the number of months in the current year for which data are available for the estimate must be specified if it is used. An example of how this feature works is as follows. Suppose the base year is 1994. The model calibrates its estimating functions on base year delivered support and observed NMCS rates. The model then estimates NMCS rates for the years 1995-1998, based on funding profiles. However, if we are 9 months into 1995 and have actual NMCS data through this period, the model will adjust the 1995 projection based on 3/4 of the year being known and will also make smaller modifications to years beyond 1995. Data for this input are obtained from the RIDB maintained by LOGSA. As stated previously, the format for the data input may require that dummy data be entered for the current year (see above).

Weapon System Activity Levels. For purposes of the NMCM calculation, the user must input historical and expected future levels of activity (OPTEMPO) for each weapon system for which OPTEMPO is defined. Some systems do not have a well-defined method of measuring activity levels (e.g., the field artillery weapons and air defense artillery weapons), and so no OPTEMPO figures can be entered for these. As stated above, the model does not try to predict NMCM values for these systems based on system usage or manpower for repair, but simply extrapolates historical NMCM trends into the future.

Manpower Availability. The NMCM calculation also uses historical and expected future levels of manpower availability to calculate future NMCM values. These include fill rates and utilization factors. There is a provision in the model to incorporate training levels as well when such information becomes more generally available. (It is assumed now that training levels are flat for all systems in the model.) For the systems that do not have an OPTEMPO defined, it is not necessary to enter manpower availability data.

3.3.1 DLR FUNDING DATA

Funding requirements and funded operating cost authority, both historical and projected, are entered on the Funding screen. An example of a Funding screen is shown in Figure 3-8. For each weapon system, both required and allocated funding data are needed for each of the 8 years. Data for the first 4 years are historical, and data for the remaining years are user estimates of future requirements and expenditures. Repair and procurement funding data for replenishment spares are used, and procurement funding for initial spares is included. Additionally, consumables funding data are included as an input. Input requirements are expressed in stand-alone terms. Figure 3-8 illustrates notional input data for OCA requirements and funding over an

8-year window for a weapon system. This figure illustrates 4 past years, including the base year, plus the current year and 3 future funding years.

3.3.2 INFLATION AND CARRYOVER FACTORS

When a system is less than fully funded, the model can carry over a portion of unfunded procurement, repair, and consumables requirements at the option of the user. This means, in practical terms, that the user expects that the system in question will still need part of the funding required in the previous year, even though time has passed. Carryover factors, which can vary among weapons systems, determine what fraction of the unfunded requirements is added to the next year's requirements and are policy variables that can be modified. (Default values used in the past were 0.25 for each, meaning that 25 percent of unfunded requirements in a specific year will remain as a legitimate requirement for the next year and will be added to that year's stand-alone requirement.)

Figure 3-8. OCA Requirements and Funding

Individual carryover factors are available for every year in the time frame being considered by the model. However, under normal circumstances the carryover factors would be used only for future years, where it is not known how much of a previous year's requirement will actually be funded. Carryover factors for the historical years would be set to zero, since it is assumed that the (historical) requirement for each succeeding

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year has already taken into account the requirement for certain items which were not previously supplied because of less than required funding. However, since it is possible, under certain reporting systems (e.g., where each requirement figure is a number which represents an earlier budget estimate not based on actual knowledge of what would be funded in the previous year), that the requirement figure does not include unsupplied items for the previous year, it is left to the user's discretion as to whether the factors are actually set to zero.

Inflation factors are those that are approved by the Office of the Secretary of Defense (OSD). They can be used to further modify the funding requirements on the assumption that unfunded carryover items will cost more in the following year. Unfunded requirements carried over to the next year are automatically multiplied by the inflation factor for that year.

There are two types of screens provided for inputting carryover factors and inflation factors — a global screen and many individual weapon screens. The global screen allows the user to set values that can be used for every weapon system without the need to input numbers for every system. The individual screens allow the user to customize the numbers for an individual system. Each individual screen offers the user the option to use global or not use global by toggling the Use Global feature on or off.

Global carryover and inflation factors are entered while in the multiple weapon systems mode, where the Carryover screen is entered through the edit menu. Figure 3-9 shows what the Global Carryover screen looks like.

Individual inflation and carryover factors are entered in the individual Carryover screen, accessed while in the single weapon system mode through the Edit menu. Figure 3-10 shows an example of a single-system Carryover screen.

3.3.3　　　PROCUREMENT LEAD TIMES

The model uses a lead time spread to express how spares are delivered over time. This spread is based on the assumption that the computed OCA requirement for a single year is based on a wide variety of procurement lead times that can be described by a lead time distribution. The values shown in Figure 3-11 indicate that, for all the dollars obligated in a given year n, 2 percent result in deliveries in year n, 10 percent in year $n + 1$, 70 percent in year $n + 2$, and 18 percent in year $n + 3$.

Figure 3-9. Global Carryover Factors Screen

Figure 3-10. Individual Carryover Factors Screen

Figure 3-11. Lead Time Factors Screen

3.3.4　　　　　MISSION CAPABLE RATES AND TARGETS

Historical mission capable rates (NMCM and NMCS), as well as availability target values, are entered in the Readiness Rates screen, accessed through the Edit menu. When RIDB data have already been imported into the model, this feature allows the user to modify these values.

3.3.5　　　　　MODEL ADJUSTMENT FACTORS

The feature that allows for adjustment of future NMCS calculations based on current year information is toggled on and off through the Current Year Adjustment screen, accessed through the Edit menu. This screen allows the user to input the observed value of NMCS for the partial current year, and the number of months on which the observation is based. An example of this screen is shown in Figure 3-12. Similarly, the user may alter previously input RIDB data for the current year with this feature.

Figure 3-12. Current Year Adjustment Menu

3.3.6   MAINTENANCE FACTORS

OPTEMPO and manpower availability are used in the calculation of predicted NMCM values. These numbers are input in the Maintenance screen, which can be accessed through the bottom tab associated with the analysis output screen for single weapon systems.

3.4   MODEL OUTPUTS AND CALCULATIONS

Included in the category of model outputs and calculations are the following:

- Army FAMMAS intermediate calculations of delivered funding (which are available to the user) and the calculation of NMCS and NMCM rates for each weapon system

- The ALAP POCM Calculations for the number of weapon systems available for operations at the beginning of each day

- The number of systems awaiting parts and maintenance

- The number of systems brought up by the day's end

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- The overall minimum wartime Mission Capable rate needed to prosecute the war, as seen from a maintenance predominate perspective.

3.4.1   FUNDING ALLOCATIONS – DLR DELIVERED SUPPORT

The first part of the Army FAMMAS calculation process is to compute delivered requirements and funding by fiscal year. Figure 3-13 shows the delivered values of funding and requirements, based on the individual year obligational values and the specified lead time factors. This screen is accessed as part of the analysis results, using the Funding tab and the Delivered button, and allows the user to see the deliveries that result from the funding values entered.

Figure 3-13. Delivered Funding & Requirements Screen

Figure 3-13 is created by spreading year **n** requirements and funding using the entered lead time factors to reflect future-year delivery requirements. Note that the purpose of carrying 3 past years of requirements and funding data becomes apparent when it is recognized that such data are necessary to complete the delivered requirement and funding for the base year, which is used for curve calibration as described later in this section. Buy and initial spares requirements are combined in the Delivered Funding table, and are represented in the DLR Buy section, to reflect the notion that, once received, DLR inventory loses its identity with respect to the source of funding.

3.4.2   **NMCS ANALYSIS — SINGLE WEAPON SYSTEM**

Army FAMMAS computes estimates of the future values of NMCS for each weapon system using the required funding for each year, the (user input) expected actual funding, the target availabilities expected to be reached when the required funding is allocated, and various assumptions about how purchased items will be delivered and how failure to meet the requirement will change the next year's requirement.

3.4.2.1   **Analytical Assumptions for NMCS Analysis**

The analysis framework of Army FAMMAS incorporates several basic assumptions, as follows:

- An MC or specified availability (1 – NMCS) target for each weapon system has been used by the Army for purposes of computing requirements.

- The buy, repair, and consumables DLR OCA requirements are specified to achieve the MC target.

- NMCS is a function of total DLR funding levels, as measured by the total purchases delivered each year.

- The effectiveness of authorized repair funding is influenced by authorized levels of consumables funding.

- The marginal sensitivity of availability to buy dollars is a function of the weapon system's relative dependence on procurement of added inventory (versus repair of existing inventory).

3.4.2.2   **Availability Curves**

A marginal return availability curve is constructed for each weapon system. The independent variable for this curve is the total amount of delivered purchases for each year measured in dollar terms, while the dependent variable is 1–NMCS, the expected availability. Each curve is constructed in four steps: (1) construct a baseline curve for the base year; (2) construct an adjusted curve for the base year that goes through the observed data point; (3) compute applicable bias factors for future years; and (4) construct adjusted curves for each assessment year.

Baseline Curve, Base Year. The baseline marginal return curve is a negative exponential curve of the type shown in equation 3-1:

$$y = 1 - (c + a\ e^{-bx}) \qquad \text{[Eq 3-1]}$$

where y represents predicted availability, x represents delivered funding, c provides an upper limit to the values that can be achieved, and a and b are parameters derived from the historical funding and availability values and the future availability goal. Its parameters are determined by the delivered funding requirements and target availability in the base year. The limiting value c is an input based on experience and has been set to 0.01 for the current model. The parameters a and b are determined in such a way as to allow the curve to pass through two points: the target availability for the base year at 100 percent funding, and a point that represents the ratio of delivered repair dollars to delivered total dollars for the base year, multiplied by the target availability. The derivation of the parameters is shown below.

As an example of how this curve is determined, consider a notional weapon system with base year delivered funding requirements of $80M for DLR repairs and $62M for DLR buys, and a target availability of 0.90 that should be achieved if these requirements are met. (These are all historical values.) Parameters for the curve are found to satisfy the following:

- One point on the curve represents the achievement of the weapon system availability target (0.90) when full DLR delivery requirements (DLR Repair plus DLR Buy) are funded for the assessment year ($142M).

- A full repair/zero-buy ($80M) availability value is computed as 0.507 based on DLR buy and DLR repair requirements. This value is obtained as the ratio of delivered repair requirement to total delivered requirement, multiplied by the target availability.

The rationale for anchoring the curve at this second point (where total delivered funding = $80M) is the premise that some level of availability is supportable through repair of existing inventory, but the level is variable, based on the relative importance of new buys. A stable system with level or decreasing activity typically shows a high DLR repair requirement relative to buy requirement; therefore, availability should be less sensitive to procurement shortfalls. Conversely, a new system that drives a very high DLR procurement requirement because of growing pipelines and safety levels will reflect a greater sensitivity to procurement shortfalls. Setting the value of the second point as above tends to reflect this philosophy.

Adjusting the Base Year Curve. The theoretical base year curve is compared to the actual observed values in the base year, which may or may not occur at full funding. Determining the predicted base year availability from the baseline curve is simply a matter of entering the value of total base year DLR deliveries, computed from previous years' funding, and reading the resulting availability. However, it is highly unlikely that the mathematical function constructed above will give a prediction that perfectly matches the observed value. Since we know the actual NMCS observed for the base year, an adjustment to the curve can be made that will allow the curve to predict accurately the actual base year value (i.e., pass through the observed point). The formal steps in the construction of a calibrated base year curve are briefly described in the following steps.

(1) Develop a baseline prediction curve for the base year (in this case 1995) with 1992-1995 funding/requirement data, using the process described above to calculate delivered funding:

The beginning point of the baseline prediction curve is the ratio of the repair requirement to the total requirement for the base year. This parameter is given by:

$$RepRatio(b) = \frac{RepOARqmt(b)}{TotOARqmt(b)} \; AVTgt(b) \qquad \text{[Eq 3-2]}$$

where

$RepOA.Rqmt(b)$ = delivered repair requirement for the base year,
$TotOA.Rqmt(b)$ = delivered buy plus repair requirement for the base year, and
$AVTgt(b)$ = availability target for the base year.

The availability equation in terms of funding is then:

$$Avail(Fund) = 1 - (CVAL + AVAL(b) \cdot e^{-BVAL(b) \cdot [Fund - RepOA.Rqmt(b)]}) \qquad \text{[Eq 3-3]}$$

where
$Fund$ = delivered buy and repair funding computed for the base year,
$CVAL$ = minimum distance of the predicted value from 1
  = $1 - AVMAX$,
$AVAL(b)$ = coefficient of the exponential for the base year
  = $AVMAX - AVMIN(b)$,
with
$AVMAX$ = 0.99 for all years and all systems in this model,
$AVMIN(b)$ = $RepRatio(b)$,

and

$$BVAL(b) = \frac{ln[AVAL(b)] - ln[1 - CVAL - AVTgt(b)]}{TotOARqmt(b) - RepOARqmt(b)} \qquad \text{[Eq 3-4]}$$

where BVAL(b) is the parameter that determines the horizontal (x-axis) shift in the exponential. Note that the parameters AVAL, BVAL, and CVAL have been determined so that if there were no money obligated to buy spares in the base year (Fund = RepOA.Rqmt(b)), then Equation 3-3 becomes

$$Avail(Fund) = 1 - (CVAL + AVAL(b) \cdot \varepsilon^0)$$
$$= 1 - (1 - AVMAX + AVMAX - AVMIN(b)) \qquad \text{[Eq 3-5]}$$
$$= AVMIN(b),$$

while if there were 100 percent funding (Fund = TotOA.Rqmt(b)) then

$$Avail(Fund) = 1 - (CVAL + AVAL(b) \cdot \varepsilon^{-BVAL(b) \cdot (TotOA.Rqmt(b) - RepOA.Rqmt(b))})$$
$$= 1 - (CVAL + AVAL(b) \cdot (1 - CVAL - AVTgt(b)) / AVAL(b)) \qquad \text{[Eq 3-6]}$$
$$= 1 - (CVAL + (1 - CVAL - AVTgt(b)))$$
$$= AVTgt(b).$$

(2) Construct an adjusted baseline curve.

The estimated availability for the base year, AvailatFund(b), as a function of the actual delivered funding for that year, TotOA.Fund(b), is obtained from Equation 3-7:

$$AvailatFund(b) = Avail[TotOA.Fund(b)] \qquad \text{[Eq 3-7]}$$

Suppose that the observed 1994 value of 1 − NMCS for the system is different from the computed value. The curve is adjusted to match the observed value in the base year by making a transformation of the x-coordinate. This is done by keeping the old BVAL(b) (to keep the shape of the curve) and changing AVAL(b) to be:

$$AVAL(b) = [1 - CVAL - ObservedAvail(b)] \cdot \varepsilon^{BVAL(b) [DlvTotalFndg(b) - DlvRepairRqmt(b)]} \qquad \text{[Eq 3-8]}$$

where ObservedAvail(b) is the actual value of 1 − NMCS observed in the base year. The resulting (adjusted) values for AVAL, BVAL, and CVAL determine the adjusted base year curve. This curve is then used to help to determine the availability curve for future years.

(3) Compute applicable bias factors.

First, the availability at full funding is calculated for the base year using the calibrated base year curve. Assuming this is not the target availability (which it is likely not to be because of step 2), the resulting NMCS value (one minus availability) is found, and is divided by the target NMCS rate (one minus target availability). This gives the target ratio. The target ratio is then multiplied by the target NMCS values for each of the succeeding years to get new target NMCS values and hence new target availabilities. These target availabilities are then used in the same way as the target availability was used in the base year to get values of AVAL, BVAL, and CVAL for each future year. Equation 3-3 is then used to calculate the predicted availability in a future year y, where values for the year y are to be substituted in Equation 3-3 for values for year b, the base year.

There is one further adjustment that occurs. The idea of multiplying the future target NMCS values by the target ratio was to adjust for the fact that the prediction of NMCS in the base year at 100 percent funding was off in one direction or another, and so the prediction at 100 percent funding will be off in the same direction in later years. However, in order to account for the fact that this discrepancy will probably diminish with time, the target ratio moves closer to 1 in each succeeding year.

These steps above are now described. Using the adjusted value AVAL(b) for the base year and Equation 3-3, compute a new target for the base year of

$$NewBaseTgt = Avail(100\%).$$
[Eq 3-9]

and a target ratio between this value and the input value, AVTgt(b).

$$TgtRatio(b) = \frac{1 - NewBaseTgt}{1 - AVTgt(b)}$$
[Eq 3-10]

This ratio is used to adjust the target for each future year before doing curve fitting. For each year y after the base year, this is adjusted by

$$TgtRatio(y) = \sqrt{TgtRatio(y - 1)}$$
[Eq 3-11]

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and the new availability target for year y is

$$NewAVTgt(y) = 1 - TgtRatio(y) (1 - AVTgt(y)).$$ [Eq 3-12]

(4) Construct adjusted curves to predict availability for each future year.

These new target availabilities just derived are used to calibrate the curve for each future year y, using the same formulas for AVAL, BVAL, and CVAL which were used originally for the base year baseline curve. The new availability targets, however, are substituted for the original targets.

As mentioned above, the user may further adjust the predicted value of NMCS to reflect current year NMCS information if desired (i.e., information for the next year after the base year). For the current year (year b + 1), the adjustment factor is:

$$AdjForYr(b + 1) = [CurObsAvail - AdjAvail(b + 1)] \frac{CumMon}{12}$$ [Eq 3-13]

where

    CumMon   =   number of months expired in the current fiscal year,

    CurObsAvail   =   observed availability for the current year, and

    AdjAvail(b + 1)   =   previously calculated value for availability estimate for year b + 1

This value is added to the estimated value of availability for the current year given by the adjusted prediction formula. For any year beyond the first year, the adjustment factor is computed by:

$$AdjForYr(y) = AdjForYr(y - 1) \cdot 0.5$$ [Eq 3-14]

With these adjustments, the effect of the difference between observed and predicted for the current year is cut in half in each succeeding year, and so the current year observed value is allowed to affect the prediction curve, but less in each succeeding year.

3.4.3   NMCS ANALYSIS — MULTIPLE WEAPON SYSTEMS

Army FAMMAS gives the user the capability to work with more than one weapon system at a time. When using Army FAMMAS in the Multiple mode, the user can see at a glance the effects on availability of

spreading buy money across several weapon systems. The availability curves explained above are computed for each weapon system and used to predict the individual availabilities. The multiple system capability of the program allows the user to view several weapon systems simultaneously and also to let the program spread buy funding. There are two automatic spreading features provided — Proportional Spread and Optimal Spread.

Proportional Spread: The Proportional Spread feature (sometimes referred to as the peanut butter spread) lets the user spread obligation buy authority in a given year evenly over several systems. The way this works is that the user first selects a group of systems and then specifies an amount of money to be spread over the buy OCA for a particular year. The model will do one of two things, at the option of the user:

(1) Straight Proportional Spread: The total amount specified is spread over all systems in the group in proportion to their buy requirements for the year in question. For instance, if there is $3M to be spread over two systems that have buy requirements of $2M and $4M respectively, then the first system will get $1M and the second $2M.

(2) Proportional Spread over minimum amount: When minimum buy amounts are specified for the weapon systems in the group, this option will spread the money left over after satisfying the constraint of funding these specified minima. The process followed is that new requirements are computed for the weapons in the group, and the total amount of money left over after satisfying minimum constraints will be spread in proportion to these new requirements, in the same way that it was spread for the original requirements when using the straight proportional spread. This option is useful, for instance, when additional funding has been added to existing funding in the current year, and there are amounts that have already been obligated by the program managers and therefore are not available to be given to other systems.

Optimal Spread: The second way in which the program will automatically allocate buy funding is the Optimal Spread. To use this option, three things must be specified: (1) the year in which to spread buy funding; (2) the amount of buy funding to spread; and (3) the assessment year or years in which availability is to be optimized, together with the priority of each such year. The program will then spread money to achieve the goals specified in each of the priority years, in their order of priority.

For the first priority year, the program calculates the amount of money needed by each system to achieve target availability in that year. If there is enough total OCA buy money to achieve this after satisfying any specified minimum amounts for weapon systems then the program goes to the next priority year, setting the amounts needed for target availability in the first year as minimum values that cannot be violated in any successive

computations. Having achieved target availability for the first year, the program continues to allocate money in such a way that the target objectives are achieved for each of the succeeding priority years.

If at any point in this computation there is not enough money to achieve target availability for all systems in an assessment year, the program allocates money in such a way as to bring all systems to a state of equal relative availability in that assessment year. (Equal relative availability means the same difference from their target availabilities. For instance, if two systems had targets of 0.90 and 0.94, then availabilities of 0.88 and 0.92 respectively would represent equal relative availabilities.) Note, however, that it may not be possible to achieve the goal of equal relative availabilities because some system may already have an availability that, with no extra funding beyond the minimum already specified for that system, cannot be reached by the other systems even when they do receive the extra funding. In that case, all such systems will receive no funding beyond their specified minimum, and the extra dollars will be allocated to the other systems to bring them up to the same levels of equal relative availability (among themselves).

If all systems can achieve target availability for all specified priority years, then there is money left over. That extra money will be allocated by the program in such a way as to try to bring all systems to equal relative availability (now **over** their target availabilities) in the first priority year. Again, the goal of equal relative availabilities may not be achievable because of minimum funding values already specified for the systems.

Since maximum amounts can also be specified for weapon systems, the spreading algorithms must abide by such inputted maximums as they do their calculations. In the case of proportional spreading this may mean taking them out of the spreading process and setting (fencing) their fundings at the maximum amounts. In the optimal spreading approach, this means not going beyond these maximums when the program calculations would indicate that higher values are appropriate.

With both the Proportional and Optimal spreads, weapon systems can be removed from the chosen group or groups before proceeding to do the spread. These are referred to as fenced systems in the program. This feature is useful when trying out different possible funding combinations when an acceptable funding has already been determined for some members of the group and it is desired to optimize or spread for others.

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3.4.4   ARMY FAMMAS MAINTENANCE MODULE

3.4.4.1   General Discussion

When a weapon system is not operational because it is undergoing maintenance (such as installation of a replacement part, repair or adjustment of some component, or routine scheduled service), it is said to be NMCM. The NMCM rate of a specific weapon system type reflects the average proportion of total possessed hours spent waiting for and undergoing maintenance of some type.

Weapon maintainability is a term used to express how easy it is to perform maintenance when it is required. Many statistics are gathered on weapon systems to measure their maintainability. Mean time to perform maintenance action is the measure of how much time, on average, it takes to repair a system when it requires maintenance. Direct production maintenance manhours per hour of use is a measure of how much effort is required by maintenance personnel to keep weapon systems in a mission-capable state. Mean units between maintenance action is the measure of how often subsystems fail, i.e., how reliable the critical components of the weapon system are. The system NMCM rate is an important indicator of both reliability and maintainability.

To a large degree, NMCM rates can be affected by a number of important resource programs. The most obvious and critical ones are as follows:

- Maintenance manpower at operating unit level
- Quantity and status of maintenance support equipment such as test equipment, test stands, etc.
- Level of training and experience of the maintenance workforce
- Inherent maintainability of the weapon system
- Component reliability
- Maintenance facilities
- Maintenance environment (peacetime or wartime)

The challenge in developing parametric functions to estimate NMCM rates in Army FAMMAS is complicated by the lack of analytical evidence that relates to resource programs. Unlike supply support, where a number of existing analytical models are accepted for resource programming purposes, modeling of maintenance support is a complex task that has largely been approached through large-scale, detailed simulation programs. Therefore, parametric estimators for Army FAMMAS were developed around intuitive relationships, applied conservatively and logically, and designed to be calibrated with available peacetime data.

3.4.4.2 Considerations for Predicting NMCM

The Army FAMMAS NMCM module operates with the same set of systems as the NMCS module, but different input data are used. There are two possible methods for the calculation of expected NMCM values for a system — projection and prediction. In some cases there are no good data for OPTEMPO for a weapon system, usually because there is no good definition of a measure of OPTEMPO for that system. It is felt that a good prediction cannot be made without knowing how much the system will be used in the future. In such cases, the model does not try to predict NMCM but rather projects the trend in NMCM values observed in prior years. When there is a good historical measure of OPTEMPO, the NMCM values are predicted for future years based on that OPTEMPO and on the maintenance manpower available.

3.4.4.3 Projecting NMCM

In the case where OPTEMPO numbers are not available, a projection of the NMCM trend is made. The method used is to average the observed values for NMCM from 1992 to the base year and to use this as a measure of the normal NMCM rate for the system. (**Note:** 1992 was singled out as the first reliable year to be used for the projection method because of the skewing of data that occurred due to DESERT STORM.) The projections for future years are a series of NMCM values that trend from the last (base year) value to the normal value, starting with larger steps and successively decreasing step size. If DIFF is the difference between the base year NMCM and the average of all historical years, then the projected value of NMCM for year y is

$$NMCM(y) = NMCM(y-1) - DIFF(y) \qquad \text{[Eq 3-15]}$$

where

DIFF(b + 1) = DIFF/2, and

DIFF(y + 1) = DIFF(y) / 2.

3.4.4.4 Predicting NMCM

When there are historical data for system usage (OPTEMPO) and available manpower, a formula is used to predict NMCM. This formula is a parameterized set of equations, with parameters to be determined in order to fit the equation to existing data. Specific parameters have been developed for the model for each of the different classes of systems (ground systems and helicopters for the current model version), but there are two parameters (activity ratio and sensitivity factor) that are determined at runtime by optimizing the fit of the

prediction curve to historical data. The fitting process is done internally to the model and requires no action on the part of the user.

It is logical to assume that NMCM rates are directly related to OPTEMPO rates, since the rate of usage will determine the rate of breakdown. A study of existing data has shown that NMCM values seem to be more closely related to OPTEMPO in the year prior to the year in question rather than that year itself. Therefore, the formulas for predicting NMCM use manpower data from the year in question and usage data (OPTEMPO) from the previous year.

The general formula used for NMCM is

$$NMCM = 1 - MFct \left[1 - \frac{(ActRatio)\ (INMCM)}{AvailMH}\right], \qquad \text{[Eq 3-16]}$$

where

Mfct	=	Maintenance Resources Factor,
INMCM	=	Base Year observed NMCM rate,
AvailMH	=	Measure of time available for maintenance, and
ActRatio	=	Activity Ratio, a parameter determined by the model.

The values of MFct and AvailMH are derived as follows. For AvailMH,

$$AvailMH = \frac{264}{OPTEMPO} - 1.44444 \qquad \text{[Eq 3-17a]}$$

in the case of helicopters, and

$$AvailMH = \frac{264}{OPTEMPO} - 3 \qquad \text{[Eq 3-17b]}$$

for ground systems. The constants in these formulas are derived individually for each class of systems and are related to the fact that OPTEMPO is measured in hours for aircraft and in miles for ground systems. In the event that other measures of OPTEMPO can be defined for other systems, it will probably be necessary to derive additional equations for AvailMH.

MFct is defined by

$$MFct = M0 \cdot \frac{M3 + M4}{M1 + M2} \qquad \text{[Eq 3-18]}$$

where M0 is related to historical values of NMCM, and M1 to M4 are related to levels of manpower availability, usage, and training, both in the base year and in the year for which NMCM is being calculated. The numerator values refer to the year being calculated, while the denominator values refer to the base year. The impact of manpower training levels was considered to have an effect on NMCM rates, but no good measurement could be found in time for this version of Army FAMMAS. An input variable for training has been left in the algorithm but is hardwired at a fixed percentage so as to have no effect on the NMCM projections.

The equation for M0 is

$$M0 = \frac{1 - NMCM(BaseYr)}{1 - NMCM(BaseYr) \cdot (ActRatio/AvailMH)} \qquad \text{[Eq 3-19]}$$

where ActRatio is a parameter to be derived by the program during the curve fitting process. The other Mi are defined as follows:

$$M1 = 1 - [1 - DSGSMp(BaseYr)]^{6 \cdot SensFctr \cdot Ute(BaseYr)} \qquad \text{[Eq 3-20a]}$$

for helicopters, and

$$M1 = 1 - [1 - DSGSMp(BaseYr)]^{0.8 \cdot SensFctr \cdot Ute(BaseYr)} \qquad \text{[Eq 3-20b]}$$

for ground systems;

$$M2 = 1 - [1 - UnitMp(BaseYr)]^{6 \cdot SensFctr \cdot Ute(BaseYr)} \qquad \text{[Eq 3-21a]}$$

for helicopters, and

$$M2 = 1 - [1 - UnitMp(BaseYr)]^{0.8 \cdot SensFctr \cdot Ute(BaseYr)} \qquad \text{[Eq 3-21b]}$$

for ground systems;

$$M3 = 1 - [1 - DSGSMp(CurYr)]^{6 \cdot SensFctr \cdot Ute(CurYr)} \qquad \text{[Eq 3-22a]}$$

for helicopters, and

$$M3 = 1 - [1 - DSGSMp(CurYr)]^{0.8 \cdot SensFctr \cdot Ute(CurYr)} \qquad \text{[Eq 3-22b]}$$

for ground systems;

$$M4 = 1 - [1 - UnitMp(CurYr)]^{6 \cdot SensFctr \cdot Ute(CurYr)} \qquad \text{[Eq 3-23a]}$$

for helicopters, and

$$M4 = 1 - [1 - UnitMp(CurYr)]^{0.8 \cdot SensFctr \cdot Ute(CurYr)} \qquad \text{[Eq 3-23b]}$$

for ground systems;

where

DSGSMp	=	Direct/General Support Manpower Factor for each year,
UnitMp	=	Unit Manpower Factor for each year,
Ute	=	Utilization Factor for all manpower for each year, and
SensFctr	=	Sensitivity Factor (to be determined by program).

Again, the coefficient in the exponent is dependent on the type of system (helicopter or ground) and may be different if other types of systems are considered.

3.5 THE ALAP POCM

3.5.1 GENERAL

The ALAP POCM attempts to evaluate the Logistic Systems capability to sustain weapon systems during contingencies and times of hostilities. The model was developed to prove the concept of linking wartime OPTEMPO, and current funding levels and budget constraints with future weapon system sustainability. This model operates with the same set of weapon systems as the Army FAMMAS NMCS and NMCM modules, the exception being the UH-60, OH-58D, CH-47D, and the M977 AVENGER. No CIF data for these particular weapon systems were produced in time for inclusion into the POCM. AH-64 data were used in place of the missing data for the aircraft, and HMMWV data were used for the AVENGER.

In the simplest of terms, the ALAP POCM is a straightforward model that replicated a weapon system during a combat scenario. It maneuvers the weapon based on the input OPTEMPO, putting as many miles, operating hours or rounds through the tubes as doctrine dictates. Based on the OPTEMPO, parts begin to fail and the system goes down for repair. The supply availability rates from Army FAMMAS are applied. If sufficient supplies exist, the weapon system is repaired. If not, it is placed in a hold, waiting parts status. If the parts needed for repair are on hand, the maintenance availability rates from Army FAMMAS are applied and the system will be repaired, provided sufficient maintenance resources are available. After repair, the weapon

system is returned to mission capable status and put back into combat. If maintenance resources are insufficient to effect repairs, the system is placed in a hold, waiting maintenance status.

3.5.2   ASSUMPTIONS AND LIMITATIONS

3.5.2.1   Assumptions

- Maintenance resources (personnel strength) are not increased to a full or C1 status. They remain as they were during peacetime. The peacetime strength is the wartime strength. Units are not augmented with personnel to fill them to the required level.

- If a system is not repaired within 48 hours, it is evacuated to the next echelon repair and never returns to a combat status.

- Initial parts supply is sufficient to support the number of systems deployed at the start of the scenario.

- Resupply is in 15-day cycles (POCM does not accommodate resupply).

3.5.2.2   Limitations

The accuracy of the breakrates and OPTEMPO (and the entire model since the breakrates are central to every calculation) are limited to the availability of CIF and MPDL data. For example, the ALAP POCM model may portray the M1 as having far fewer losses due to parts failure than past observation of this weapon system may suggest. One cause of this is that the wartime OPTEMPO available for the M1 was based on Hours of Operation. Because of this OPTEMPO, breakrates for this system were based on parts that were tracked by operating hours (such parts include circuit cards, thermal sights, etc.). The spares and components of the M1 that are tracked by operation hours have a higher operating tolerance than those parts tracked by miles. This gives the M1 a better sustainment posture than would be actually observed.

3.5.3   PREDICTING SUSTAINMENT

The OPTEMPO of a weapon system during battle is influenced by numerous elements — terrain, opposing force, or mission scenario. It would be difficult to input every influencing factor and still meet the model primary goal of being a rapid analytical tool. The compromise was to use the Area of Operation OPTEMPO

devised by the Training and Doctrine Command (TRADOC) and used in its Operations Logistics Planner. At one point it was debated whether to randomize the daily OPTEMPO between the range suggested by TRADOC, but it was agreed to use the following equation for the OPTEMPO:

$$OPTEMPO = Theaterate * Wpns^{*Sensfct} \qquad \text{[Eq 3-24]}$$

It is logical to assume that the rate of spares failure is proportional to usage. This fact is substantiated by the CIF data collected for use in the POCM. The Failures are determined as follows:

$$Failure = OPTEMPO * Breakrate * Wpns^{*SensFct} \qquad \text{[Eq 3-25]}$$

Where Breakrate is a function of the number of failures observed over a specified period of OPTEMPO

The number of spares required is calculated by:

$$PLLreq = Parts * Failure \qquad \text{[Eq 3-26]}$$

Where Parts = the number of parts per instance of failure

To determine the availability of spares, the required parts must be matched with available spares. The available spares are calculated by:

$$Parts * WpnNMC - PrevFail \qquad \text{[Eq 3-27]}$$

If sufficient spares are available to support the repair, the systems go to maintenance.

If the number of systems repaired equals the number of systems waiting for repair, no systems are put into the hold, waiting maintenance category — all are returned to mission capable status.

These calculations are repeated for each day of the scenario. The final calculation is to determine a minimum MC rate as expressed from a maintenance biased perception.

3.5.4   MINIMUM WARTIME MC RATE

The minimum MC rate for wartime is defined in terms of the minimum Peacetime MC rate that results in no loss of weapon systems relative to those portrayed over the course of the combat scenario. To estimate the variable, the ALAP POCM iterates through the entire scenario beginning with initial values of peacetime MC rates and increasing them by a factor of .01 until no systems are lost. During this calculation, the attrition is turned off and spares are held constant at 100 of the initial inventory rate that results.

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SECTION 4

ENVIRONMENT

4.1   EQUIPMENT ENVIRONMENT

Minimum FAMMAS and ALAP POCM equipment requirements are an 80386- or 80486-type microcomputer with 4MB of RAM and 15MB of available hard disk space. The model will automatically detect and access an 80x87 math coprocessor. The recommended system configuration is an 80386 with an 80387 math coprocessor or an 80486 or Pentium, and a 40MB or bigger hard disk. To produce hard copies of any graphics, a Hewlett Packard Laserjet or HP-compatible printer is required. Text hard copy can be produced on any line printer.

4.2   SUPPORT SOFTWARE ENVIRONMENT

FAMMAS/ALAP is implemented using Borland Delphi with the Microsoft Disk Operating system (MS-DOS) and Windows 3.1 on an IBM-compatible microcomputer. Windows 95 and OS/2 may also be used with the FAMMAS program. Software maintenance requires a Borland Delphi compiler and MS-DOS Version 5.0 or later with supporting documentation. If it is desired to make FAMMAS/ALAP a part of a network, then the network version of Delphi must be used. FAMMAS/ALAP data files are maintained using the Borland Database module.

4.2.1   GRAPHIC OVERVIEW

Figure 4-1 illustrates the flow of information into the DMM of FAMMAS/ALAP from other databases or models. This information is currently typed in by the user.

4.2.2   ADP OPERATIONAL IMPACTS

Army FAMMAS/ALAP's impact on ADP operations will vary by the nature of the users' roles and responsibilities. In most cases, however, Army FAMMAS/ALAP will probably be one of a number of systems sharing microcomputer resources. Users will need to learn how to operate the model, how to acquire and manipulate input information, and how to understand and apply the model's results within the scope of user responsibilities.
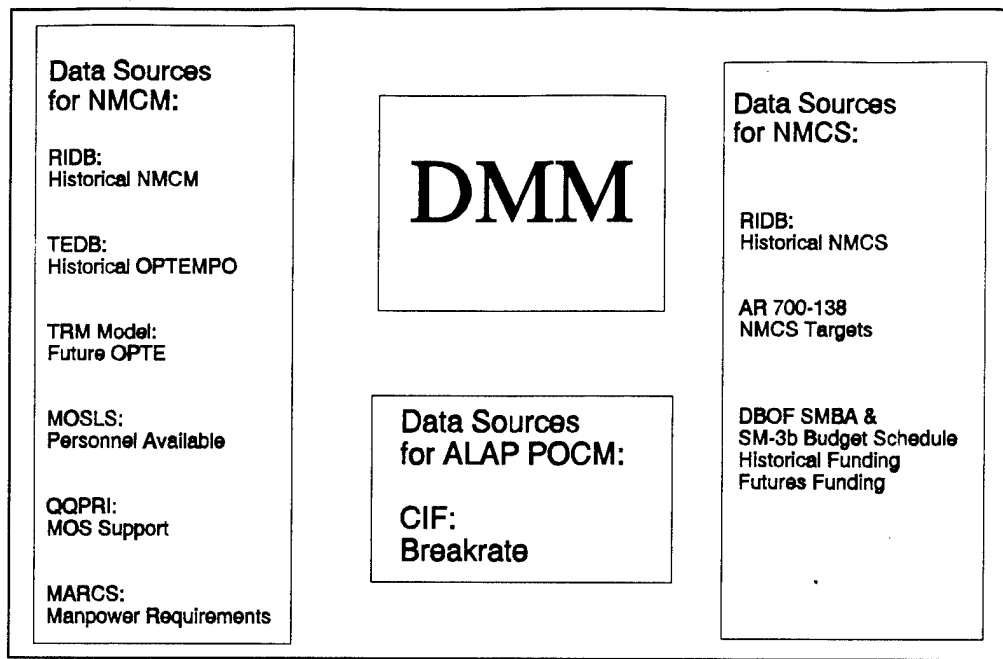
Figure 4-1. Data Input for FAMMAS

4.3 FAILURE CONTINGENCIES

In preparation for system failures, a working copy of the model and the associated data should be kept on floppy disks or on a cassette tape cartridge.

4.4 ASSUMPTIONS AND CONSTRAINTS

Underlying assumptions and constraints include the following:

- Certain Army FAMMAS input will continue to be collected manually.

- Army FAMMAS will be operated on microcomputers located in vaults or secure locations when operating with classified data. Army FAMMAS will share these microcomputer resources with other applications.

- Segments of the model's logic and algorithms have been subjected to prior validation and approval as part of other functioning models currently used by the military to predict NMCM and NMCS rates. They will contribute to the decisionmaking process by graphically demonstrating relationships known to exist but that have previously been formally unquantified.

The ALAP POCM has not been validated nor tested. Although the spreadsheet model from which ALAP was engineered routinely returned consistent values based upon test input, it has not been validated against Army data. Subsequently, the ALAP POCM has not been validated and has been tested only to the extent that such testing did not conflict with the completion of the project within the allotted time.

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SECTION 5
SECURITY

Army FAMMAS/ALAP operates in an Unclassified mode. Therefore, the user who wishes to process classified information must take safeguards to control such things as visual and electronic access to the data stored in the program as well as to data stored on the fixed disk or on removable disks. The same is true when hard copy or file outputs are made from the program's database. It is the user's responsibility to see that all points in the transmission of information, as well as the final repository for such information, are secured to the level required.

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SECTION 6
COST FACTORS

Because Army FAMMAS/ALAP runs on a single microcomputer, its initial equipment cost is limited. Most functional staff offices engaged in logistics analysis already possess or have access to appropriate hardware and software that would enable them to employ Army FAMMAS/ALAP. Therefore, no new cost factors are related to the proposed system.

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APPENDIX A

ARMY FAMMAS MODEL AUTOMATED DATA SOURCE LISTINGS

A-1   OVERVIEW

The Army FAMMAS Model facilitates the retrieval of selected data from four primary sources through its FMS. Information from these sources is imported into DBase IV through either ASCII text files or spreadsheet files, and this information is then saved in the DBase format. In the early development of the model, the Army desired that any database files used within the model be compatible with FOXPRO. DBase IV files are compatible with this file format.

Data are drawn from one of four sources: RIDB, TAMMS, MOSLS, and the CIF. Each source is an Army-managed database. The following section gives a brief description of these sources and lists the Army and Synergy point of contact (POC) if both exist.

A-2   DATA SOURCES

A-2.1 Readiness Integrated Data Base (RIDB) — The RIDB is a database maintained by the LOGSA and is a compilation of all of the Army's equipment readiness data. The database compiles and consolidates equipment readiness data from DA Forms 2406 (ground equipment), 1352 (aircraft), 3266-1 (missiles), and the Army Materiel Status System (AMSS). The database provides the historical NMCS and NMCM rates that the Army FAMMAS model uses for its weapons system readiness predictions.

Access to this database is obtained through Linda Thompson of LOGSA, (205) 955-9718. Synergy's POC is Mike Austin, (202) 232-6261. LOGSA provides a text file of the RIDB data to Synergy via e-mail, which is imported into the FAMDS data files contained within the model.

A-2.2 The Army Maintenance Management System (TAMMS) Equipment Database (TEDB) — The TEDB is a database maintained by LOGSA and contains records on selected serially numbered major end items of equipment. The information on the major end items is used for fleet management reports, which provide selected information such as age, miles, usage, and operating tempo (OPTEMPO). The database provides the historical OPTEMPO rates that the Army FAMMAS model uses for its weapons system readiness predictions.

Access to this database is obtained through Linda Thompson of LOGSA, (205) 955-9718. Synergy's POC is Mike Austin, (202) 232-6261. LOGSA provides a text file of the TEDB data to Synergy via e-mail, which is imported into the FAMDS data files contained within the model.

A-2.3 Military Occupational Level System (MOSLS) — A study was done of existing NMCM data and the factors that correlate with them. The analysis of the data showed that NMCM values in a particular year are related to the manpower available in that year for repair work but are related to OPTEMPO more closely in the year **prior to** the year in question. Formulas have been set up accordingly. This data source is a personnel planning optimization model that computes recommended MOS and grade mix, enlisted accessions, training to support accessions and in-service reclassification/reenlistment and promotions to maintain force alignment throughout the POM cycle. The data provided from this model are the current personnel strength on hand as well as the projected strength by MOS, and by grade and by fiscal year.

Access to this database is obtained through Anna Taylor of U.S. Total Army Personnel Command TAPC-PLP, (703) 325-4252. Synergy's POC is Mike Austin, (202) 232-6261. TAPC provides a text file via diskette to Synergy, which is imported into the FAMDS data files contained within the model. The data are obtained on a diskette in text format.

A-2.4 Candidate Item File (CIF) — A constrained list of class IX spare/repair parts. It is normally used in conjunction with the Optimum Stockage Requirements Analysis Program model. The output of this process is a recommended set of Class IX parts intended to support a specific unit in a hostile/intensive use mission environment. As such, the CIF is restricted to parts that are combat essential, Line Replaceable Units removed at the organizational/Direct Support Maintenance levels.

Access to this database is obtained through Malcolm Conlee of the Customer Support Center, U.S. Army Materiel Command Logistics Support Activity (LOGSA), (205) 955-9597. Synergy's POC is Mike Austin, (202) 232-6261. LOGSA provides a text file of the CIF data via Linda Thompson of LOGSA, (205) 955-9718, through e-mail. The data are then manipulated to give parts-per-incidence of failure and breakrates. These data are then configured into a compatible database and placed in the DMM.

A-3   **INFORMATION**

Please refer all questions on accessing, downloading, or uploading these sources to Richard Haynes, Synergy, Inc., (202) 232-6261.